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Density and distribution nest site selection and activity of the mountain plover on the Charles M. Russell National Wildlife Refuge

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DENSITY AND DISTRIBUTION, NEST SITE SELECTION, AND ACTIVITY OF THE MOUNTAIN PLOVER ON THE CHARLES M. RUSSELL NATIONAL WILDLIFE REFUGE

BY

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ABSTRACT

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Density and Distribution, Nest Site Selection, and Activity of the Mountain Plover on the Charles M. Russell National Wildlife Refuge (62 pp.)

Director: I. J. Ball

Mountain Plover (Charadrius montanus) density, distribution, nest site selection, activity patterns, and insect diversity and abundance on and off black-tailed prairie dog (Cynomys ludovicianus) towns were studied from April through August in 1981 and 1982 on the Charles M. Russell National Wildife Refuge. Bird numbers and locations were recorded both years; 98% of all observations occurred on prairie dog towns. Breeding Mountain Plovers were found on 16 prairie dog towns, 14 of which were within the Western Unit. Towns used by Mountain Plovers were all ≥ 6 ha and on upland level sites; all were grazed by cattle and had short (< 10 cm) vegetation. Estimated Mountain Plover density on the Western Unit of the Refuge was 0.28 birds per km^2. Twenty-six nest sites, all on prairie dog towns, were measured for vegetative characteristics and compared with a random sample of sites on and off prairie dog towns. Total plant cover, grass cover, big sagebrush and prickly pear density, and mean vegetation height were all significantly lower at nests than at off-town sites but litter cover and fringed sage density were greater at the nest sites. Within towns, erosion pavement cover and mean vegetation height were lower at the nest sites than at random sites. Mountain Plovers apparently select areas within the town with greater vegetative cover but less height and less erosion pavement than was available on the town.

Insects were captured in pitfall traps located on and off of a prairie dog town. Total insects and number of species per trap were similar for 4 collections. Coleopteran densities were significantly greater on-town when the 4 collections were pooled. Ant densities increased significantly between the second and third collections. Mountain Plover food items, with the exception of orthopterans, which were not sampled adequately, occurred in greater numbers on the town.

Mountain Plover behavior was recorded during the second season. Courtship, locomotion, and maintenance activities decreased with increasing temperature on a daily and seasonal basis. This appears to be an adaptation to the hot arid conditions on the short-grass prairie.

PREFACE

This thesis is written in five sections, in agreement with my graduate committee and the University's policy of accepting manuscripts in lieu of a conventional thesis format. The first section is a general introduction. The second section entitled "Density and Distribution of the Mountain Plover on the Charles M. Russell National Wildlife Refuge" is written in a style to be submitted to the Wilson Bulletin. The third section, "Nest Site Selection of the Mountain Plover on the Charles M. Russell National Wildife Refuge", is written in a style to be submitted to the Journal of Range Management. The fourth section, "Insect Abundance and Species Diversity On and Off a Prairie Dog Town", is in the style of The Prairie Naturalist. The last section, "Activity Patterns of the Mountain Plover on the Charles M. Russell National Wildlife Refuge" is prepared for The Murrelet.

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Drs. B. W. O'Gara and I. J. Ball provided guidance, suggestions and help in planning this project, and critically reviewed the manuscript. I also thank Dr. D. Jenni for his suggestions and critical review, and Dr. R. Hutto for technical assistance.

Field assistance was volunteered by Bernie and Susie Peyton, Mary Harris, Susan Gray, Laurie Waylander, Diana Bedient, Gary Edge, Judy Hernon, my brother Hal, and my sister Jeanne. I thank Refuge personnel for their assistance, particularly Boyd Bergum, who saved the day more than once, and Ralph Fries, for his interest in this project.

Many thanks go to Pamela and Craig Knowles for their encouragement, enthusiasm and assistance, and for introducing me to the Breaks and Mountain Plovers. I thank my mother for many things, including her unfailing support and confidence in me throughout my pursuits, and for first introducing me to birds. Finally, special thanks to Daniel Edge, for his ever-present encouragement, good humor, energy, and invaluable help during all stages of this project.

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CHAPTER I

INTRODUCTION

Mountain Plovers (Charadrius montanus) are summer residents on the high short-grass prairies east of the Rocky Mountains. Historically they occupied a wide range on the Great Plains including Montana, North Dakota, Nebraska, Kansas, and south to Texas (Bent 1929). Coues (1878:634) described them as "breeding in considerable numbers" in northcentral Montana. Populations have declined and the Mountain Plover is now absent or incidental over most of its former range. North Dakota now lists it as an extinct species (Faanes and Stewart 1982). Lock (1975) believes the Mountain Plover in Nebraska may be endangered. Recent studies indicate that the main breeding range lies within Montana, Wyoming, and Colorado (Graul and Webster 1976); reports of breeding plovers elsewhere are sketchy or indicate small isolated populations. Watts and Eichhorn (1981) compared records of breeding birds in central Montana, and now list the Mountain Plover as casual, with 1-2 records per decade, when in 1903 it was considered a regular summer visitor. Flath (1979) listed the bird as a "nongame species of special interest or concern" in Montana. The Mountain Plover was placed on the United States Department of the Interior's "status undetermined" list in 1973 due to reports of declining numbers and habitat (Graul and Webster 1976). Dryland agriculture, cultivation, range improvements, and surface mining are all major causes of this habitat loss over large areas of short-grass prairie (Cooke 1915, Laun 1957, Lock 1975, Peart 1980, Watts and Eichhorn 1981).

The southern half of Phillips County, Montana, which includes the Charles M. Russell National Wildlife Refuge (CMR), is near the northern limits of Mountain Plover distribution, and Knowles et al. (1982) believe this area contains the highest density of breeding plovers in Montana. Breeding Mountain Plovers, but not major populations, have been reported in southern Canada (Soper 1941, Peart 1980, Wallis and Wershler 1981).

The Mountain Plover apparently evolved along with grazing ungulates on the short-grass prairie, and highest populations occur on flat, heavily grazed areas with short vegetation (Graul and Webster 1976). In the first published ecological account of Mountain Plovers in Montana, Knowles et al. (1982) found selective use of black-tailed prairie dog (Cynomys ludovicianus) towns on the CMR for breeding, nesting, and feeding. Prairie dog towns are generally located on level areas, are heavily grazed by cattle, and have short vegetation. Increasing pressure to reduce prairie dog towns in this area could result in further loss of plover habitat and a reduction of the population.

In view of the dwindling population, the lack of knowledge of this species in Montana, and the unique association between Mountain Plovers and prairie dog towns, this study was designed to investigate the density, distribution, and ecology of the Mountain Plover on the CMR.

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CHAPTER II

DENSITY AND DISTRIBUTION OF THE MOUNTAIN PLOVER ON THE CHARLES M. RUSSELL NATIONAL WILDLIFE REFUGE

Mountain Plover numbers have declined in Montana since Coues (1878:634) found them "breeding in considerable numbers" in the Milk River area, now north Phillips County. Cameron (1907) noted 2 to 3 breeding pairs of Mountain Plovers on prairie dog towns in southeastern Montana (Custer County), but only circumstantial evidence remains of this species breeding there now (Skaar 1980). Breeding birds have been reported south of the Little Snowy Mountains in Golden County (Haglan 1982), in Valley County near Glasgow (Green 1982), and on black-tailed prairie dog (*Cynomys ludovicianus*) towns in Phillips and Blaine Counties (Knowles and Knowles 1985, Erb, pers. comm.), but the highest Mountain Plover densities are believed to occur in the south Phillips County area. In 1906, a list of birds was compiled for 6 counties in central Montana, and included the Mountain Plover as a regular summer resident; the current status of this species for the same area is "casual", with one to two records per decade (Watts and Eichhorn 1981). This decline, along with that of the Long-billed Curlew (*Neumenius americanus*) in the same area, is probably due to the widespread conversion of native prairie to agricultural land. The decline also may be due in part to the extensive reduction in prairie dog populations earlier this century; Knowles et al. (1982) found that Mountain Plovers selectively inhabit black-tailed prairie dog towns throughout the breeding season on the Charles M. Russell National Wildlife Refuge (CMR). These towns apparently provide necessary habitat for the species and all are characterized by being heavily grazed, level sites with short vegetation.

My objectives for this study were to determine the number and distribution of prairie dog towns on the CMR inhabited by Mountain Plovers and to determine the breeding densities of Mountain Plovers on prairie dog towns. With declining populations and habitat loss, it is important to record the occurrence of the Mountain Plover in south Phillips County, which appears to be the breeding stronghold of the Mountain Plover in Montana.

STUDY AREA

The study area (Fig. 1) is located in northcentral Montana within the Western Unit of the CMR, which comprises 560 km^2 on the north side of the Missouri River. The area is approximately 100 km northeast of Lewistown and 100 km southwest of Malta, in Phillips County.

This area is a high eroded plateau, elevation 920 m, characterized by rugged timbered breaks, deep-cut coulees, steep ridges, and fertile riverbottoms. Major ridgetops, which are flat and broad, run primarily north-south and broaden progressively to become continuous rolling prairie toward the northern boundary of the Refuge. The Little Rocky Mountains are about 30 km to the north. The area is well-roaded and is

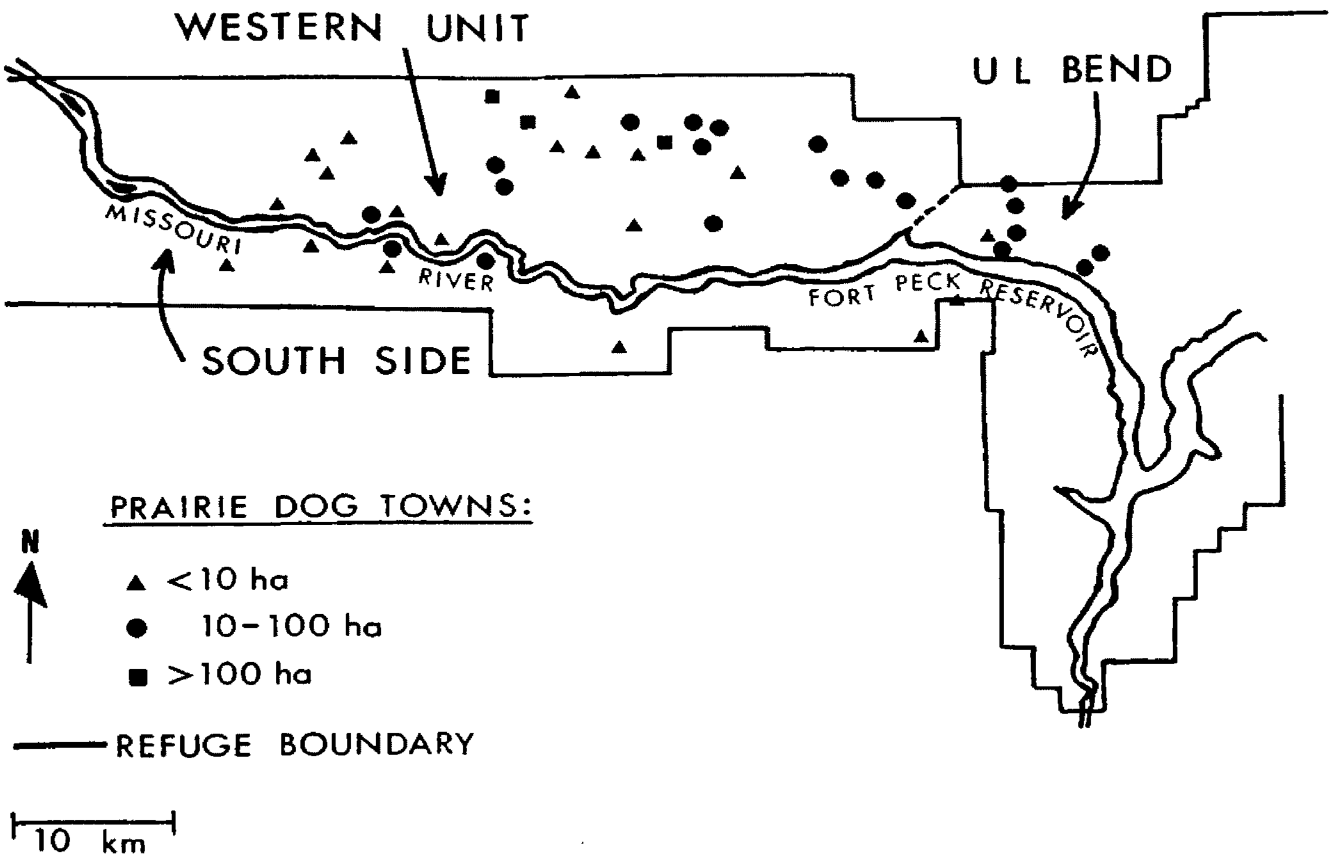

Fig. 1. Study area on the Charles M. Russell National Wildlife Refuge showing prairie dog towns surveyed.

easily accessible by vehicle in dry weather.

Ponderosa pine (_Pinus ponderosa_), interspersed with Rocky Mountain juniper (_Juniperus scopulorum_) thickets, dominate north-facing slopes. The principal plant species found on the broad ridgetops are western wheatgrass (_Agropyron smithii_), blue grama (_Bouteloua gracilis_), prickly pear (_Opuntia polyacantha_), fringed sagewort (_Artemisia frigida_) and big sagebrush (_A. tridentata_). The climate, topography, and vegetation of the area were described in detail by Knowles (1982).

Black-tailed prairie dog towns, which occupy about 1.6% of the study area, are typically located on the level broad ridgetops and are considered by Knowles et al. (1982) to represent a distinct habitat type. Prickly pear, fringed sage, blue grama, western wheatgrass, and a variety of forbs prevail, interspersed with areas of erosion pavement.

In addition to the study area described above, I also conducted censuses on prairie dog towns in the U. L. Bend area and on the south side of the Missouri River.

METHODS

From April through August of 1981 and 1982 I recorded Mountain Plover sightings throughout the study area, both on and off prairie dog towns. Research by Knowles et al. (1982) indicated that Mountain Plovers selectively use prairie dog towns, but I surveyed all areas that appeared to be potential plover habitat. At approximately 10-day intervals, in fair weather, I surveyed 10 prairie dog towns within my major study area in the Western Unit. Towns in the U. L. Bend and south side units were visited at least once during the breeding season.

Censuses did not include flocked birds because flocks exhibited considerable between-town movement, both early and late in the season. Censuses were conducted on foot, on a 3-wheeled Honda 90 all-terrain cycle (ATC), or from a truck in several of the smaller (6 to 20 ha) towns, traversed by roads. All truck travel was restricted to existing roads. Total counts were possible because of good visibility in the short and sparse vegetation of the towns. Breeding bird density estimates were calculated as number of Mountain Plovers/100 ha of available habitat on the CMR. A Spearman rank correlation (Siegel 1956:202) was used to test the strength of the relationship between prairie dog town size and Mountain Plover density, and town perimeter and plover density, for both years.

RESULTS

Mountain Plovers arrived on the CMR by 4 April 1981 and by 10 April 1982. After arrival, they remained in flocks for up to 10 days before dispersing onto breeding territories. Adults began flocking again as early as 9 July 1981, and 6 July 1982.

During 1981 and 1982, 98.8% of all Mountain Plover sightings were on prairie dog towns. In cases where birds were off of towns, they were within 0.75 km of a prairie dog town, in habitat similar to that found within towns.

Twenty-seven active prairie dog towns on the north side of the Missouri River were surveyed for Mountain Plovers at least once in 1981, 26 of these were in the Western Unit and 1 was at U. L. Bend. In 1982, 42 towns were visited; 27 of these were Western Unit towns, 7 were in

U. L. Bend, and 8 were on the south side of the river.

I censused a total of 27 towns within the Western Unit, 10 of which comprised my primary study area. Most towns in this area were found on level ridgetops. Fourteen of the 27 (52%) contained Mountain Plovers (Table 1), were a mean size of 56 ha, and accounted for 93% of the prairie dog town area in the Western Unit. The 13 towns without plovers were an average size of 5 ha, and included 4 bottomland towns. These bottomland towns were small ($\bar{x}$=7 ha), and had more slope, more vegetative cover, and less erosion pavement than upland towns. They also commonly contained greasewood (<u>Sarcobatus vermiculatus</u>).

I surveyed 7 towns in the U. L. Bend area ($\bar{x}$=40 ha), most of which occurred in bottoms of broad, low, gradual drainages. Only 2 (29%) of these towns contained Mountain Plovers,($\bar{x}$=66 ha). U. L. Bend towns without plovers ($\bar{x}$=32 ha) appeared to have more vegetation, including greasewood, with less erosion pavement than the 2 towns with plovers. It was also my impression that these towns had lower prairie dog densities than Western Unit towns. Crested wheatgrass (<u>Agropyron crisatum</u>) had been planted in part of 1 town, which created a tall vegetative profile.

In 1982, 8 towns ($\bar{x}$=8 ha) were surveyed on the South Side, west of the Chain Buttes area. Fewer towns occurred on the south side, and they tended to be smaller and farther apart than northside towns. Knowles (1982) attributed this to the topographic irregularities at bottomland sites and the lack of broad ridgetops in this area. Mountain Plovers were not observed on any of these towns, although several, probably migrating individuals, were occasionally seen on the South Side by

Table 1. Number of prairie dog towns by size class surveyed in 3 areas on the Charles M. Russell National Wildlife Refuge, 1981 and 1982. Values in parentheses are the number of towns with breeding Mountain Plovers.

	Town Area in Hectares						
Town Classification	0-5	6-10	11-50	51-100	101-300	>300	Total
South Side	3(0)	3(0)	2(0)	0	0	0	8(0)
West Unit: Upland	6(0)	2(2)	12(9)	0	2(2)	1(1)	23(14)
Bottomland	3(0)	1(0)	0	0	0	0	4(0)
U. L. Bend	1(0)	1(0)	3(1)	2(1)	0	0	7(2)
Total	13(0)	7(2)	16(10)	2(1)	2(2)	1(1)	41(16)

Refuge personnel. South Side towns were characterized by taller vegetation (usually > 10 cm), more grass cover, less erosion pavement, and more slope than northside towns.

Mountain Plover densities were calculated as adult birds per 100 ha of prairie dog town, and were estimated from censuses of my 10 principal prairie dog towns on the Western Unit, throughout both seasons. The mean number of breeding plovers per 100 ha in the 10 towns was 16.2 in 1981 and 19.6 in 1982, and the 2-year average was 17.5 Mountain Plovers per 100 ha of prairie dog town. Prairie dog towns occupy only 1.6% of the study area which is 560 km^2; therefore the estimated Mountain Plover density was 0.28 birds per km^2 for the entire area. On a town-to-town basis, town size was negatively correlated with plover density for 1981 (r_s=−0.855, $P<0.01$) and 1982 (r_s=−0.627, $P<0.05$). Dog towns of 6 ha appeared to be the minimum size necessary to support Mountain Plovers, and towns in the 6-50 ha size class seemed to support optimal plover densities, which decreased as town size increased to over 100 ha. This was also true for dog town perimeter; bird densities decreased as town perimeter increased (r_s=−0.855 for 1981, r_s=−0.842 for 1982, $P<0.01$).

DISCUSSION

Mountain Plovers arrived at their Montana breeding grounds by early April, about 2 weeks later than arrivals in northeastern Colorado (Graul 1973). Prairie dog towns on the CMR were used by Mountain Plovers for breeding, nesting, and feeding. Nearly all Mountain Plover observations were made on prairie dog towns during the 2-year study. McCullen (1965) mentioned numerous Mountain Plovers nesting on prairie dog towns on the CMR and noted that they were "never far from a prairie dog town".

All towns occupied by Mountain Plovers had several characteristics in common: they were located on upland level areas, they were at least 6 ha in size, vegetation was short, and all were moderately to heavily grazed by cattle on a 4-year rest-rotation grazing system. Knowles et al. (1982) also noted plover use on active upland towns, 81% of which were greater than 10 ha. Towns not used by Mountain Plovers were generally less than 6 ha, or if larger, had irregular topography or vegetation growing over 10 cm high throughout the town. Mountain Plovers did not occur on inactive towns, or on bottomland towns, which generally had greater slope, less horizontal visibility, and a higher incidence of greasewood than upland towns (Knowles 1982), and less cattle use. Towns of less than 6 ha apparently were too small to support breeding Mountain Plovers; Graul (1980) noted that in Colorado, Mountain Plovers were absent from "small isolated tracts of shortgrass prairie" that he thought to be ideal nesting habitat otherwise.

Upland towns within the Western Unit apparently offered the most suitable Mountain Plover habitat. More towns in this area contained higher densities of Mountain Plovers than did the U. L. Bend towns. During a 1964 prairie dog survey, Barret et al. (1964) reported numerous Mountain Plovers on towns at the west end of the Refuge, and Waite and Sellers (1966) noted that the "Mountain Plover was noticed only in the Western part". Both reports mentioned that the Burrowing Owl (<u>Athene cunicularia</u>) was seen primarily in the eastern part of the Refuge. I observed Burrowing Owls more frequently in the U. L. Bend area, as did

Knowles (pers. comm.). Mountain Plovers may avoid areas of Burrowing Owl occurrence, although owl predation on plover adults or chicks has not been documented. The U. L. Bend towns appeared to have lower prairie dog densities and more vegetative cover; these factors may also decrease Mountain Plover habitat suitability.

Mountain Plover densities between towns varied, with towns between 6 and 50 ha receiving higher plover densities than larger towns of 100 to 300 ha. Larger towns appeared more denuded, with less overall vegetation than the smaller towns. Knowles (1982) found that average prairie dog densities of larger towns were much lower (4.2/ha vs 13.9/ha) than average densities for smaller towns. He attributed this to the greater concentrations of cattle in the larger towns which resulted from numerous water developments. Mountain Plovers occur in areas with erosion pavement and vegetation less than 10 cm high, but they tend to choose nest sites near small clumps of forbs or fringed sage, generally with less erosion pavement than occurs throughout the town as a whole (Olson and Edge 1985). Smaller towns probably offered more suitable habitat in this respect. Other factors could be responsible for the higher bird densities on smaller towns; other studies, particularly on waterfowl, have revealed the same tendency, on islands rather than prairie dog towns (Geis 1956, Buss and Wing 1966, Martin 1981).

Prairie dogs modify vegetation over time (Koford 1958, Bonham and Lerwick 1976, Hansen and Gold 1977), and because of continuous clipping, favor the establishment of low-growing forbs and grasses. Heavy cattle concentrations can denude an area and reduce nesting habitat for

Mountain Plovers, but some grazing appears to be necessary to maintain prairie dog towns (Hansen and Gold 1977, Knowles 1982), and therefore Mountain Plover habitat in this area. Moderate grazing in conjunction with prairie dog activities seems to create ideal Mountain Plover habitat, by maintaining a low vegetative profile. All but 2 towns with breeding Mountain Plovers throughout my entire study area were located around stock ponds, and cattle tended to concentrate in these areas. Sixty-two percent of all town sites throughout the CMR contained livestock development of some sort, usually reservoirs or wells (Knowles 1982). Grazing has been an important determinant of Mountain Plover habitat elsewhere in its range (Bent 1929, Laun 1957, Jurek 1973, Graul and Webster 1976, Graul 1980), but on the CMR, cattle grazing alone did not provide suitable habitat. No Mountain Plovers were observed in areas of heavy cattle grazing without prairie dog towns. I believe that the absence of big sagebrush, along with the short vegetation overall, is one of the primary reasons that Mountain Plovers select prairie dog towns, which exist as "islands" of short vegetation within a shrub-grassland habitat dominated by big sagebrush (Knowles 1982). Prairie dogs have been shown to eliminate big sagebrush from towns by selective clipping (Koford 1957, Bonham and Lerwick 1976, Hansen and Gold 1977).

An overall density estimate of 17.5 birds per 100 ha of prairie dog town habitat is about one third higher than the 13 birds per 100 ha of dog town, presented by Knowles et al. (1982) as a representative density for this area. I estimated Mountain Plover density at 0.28 birds per km^2 for the Western Unit study area, compared to Knowles' estimate of

0.20 for the same area. Both estimates are considerably lower than that projected by Graul and Webster (1976) of 8.0 birds per km^2 where breeding populations exist in Montana. They estimated a population of 88,400 birds for the Montana-Wyoming area. I believe that this figure vastly overestimates Mountain Plover numbers in Montana. If my estimate of 0.28 birds per km^2 of occupied range is used to project a rough approximation of plover numbers in Montana, under the optimistic assumption that 5% of Montana east of the Continental Divide is potential Mountain Plover habitat, the result is approximately 4,000 birds. More work needs to be done to better understand this species' status within the state, but the numbers must be far less than previously believed.

The Mountain Plover is 1 of 15 grassland species endemic to the Great Plains and is considered to be a stenotopic species (Graul 1980). Rotenberry and Wiens (1980) referred to the Mountain Plover as a species with low niche breadth and therefore a narrow range of habitat specificity. As such, and considering its reduced populations, loss of habitat, and the uncertain status of the prairie dog towns which support it in northcentral Montana, this species should be given special attention in any management plan for this area.

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CHAPTER III

NEST SITE SELECTION BY MOUNTAIN PLOVERS
ON THE CHARLES M. RUSSELL NATIONAL WILDLIFE REFUGE

Mountain Plovers (*Charadrius montanus*) typically breed in upland short-grass prairies of the western Great Plains, primarily in Colorado, Wyoming, and Montana (Graul and Webster 1976). Nearly all descriptions of Mountain Plover breeding habitat have portrayed nesting sites as level, heavily grazed areas with short vegetation, usually dominated by blue grama grass (*Bouteloua gracilis*) (Bradbury 1918, Bent 1929, Soper 1941, Graul 1975, Lock 1975, Johnson and Spicer 1981, Wallis and Wershler 1981). Vegetation type, slope, and characteristics of Mountain Plover nest sites were described by Graul (1975) in northeastern Colorado. Other studies described nest scrapes and lining materials (Hoskin 1893, Bradbury 1918, Goodrich 1945:195, Laun 1957) but recorded no general habitat measurements. On the Charles M. Russell National Wildlife Refuge (CMR) in northcentral Montana, Mountain Plovers select black-tailed prairie dog (*Cynomys ludovicianus*) towns for breeding, nesting, feeding, and rearing young (Knowles et al. 1982). This affinity for prairie dog towns has not been noted elsewhere. Declining populations and habitat loss throughout wide portions of Mountain Plover range intensify the need for improved knowledge of this species' habitat requirements.

The objective of this study was to quantify vegetative characteristics of Mountain Plover nest sites, and compare these characteristics to random sites on prairie dog towns and adjacent areas.

Study Area

The study area is located in northcentral Montana within the Western Unit of the CMR, which comprises 560 km^2 on the north side of the Missouri River. The area, in Phillips County, is approximately 100 km northeast of Lewistown and 100 km southwest of Malta.

This area is a high eroded plateau, elevation 920 m, characterized by rugged timbered breaks, deep-cut coulees, steep ridges, and productive riverbottoms. Major ridgetops, which are flat and broad, run primarily north-south and broaden progressively to form rolling mixed-grass prairie toward the northern boundary of the Refuge. The area is well-roaded and is easily accessible by vehicle during dry weather.

Ponderosa pine (*Pinus ponderosa*), interspersed with Rocky Mountain juniper (*Juniperus scopulorum*) thickets, dominate north-facing slopes. The principal plant species found on the broad ridgetops are western wheatgrass (*Agropyron smithii*), blue grama, prickly pear (*Opuntia polyacantha*), fringed sage (*Artemisia frigida*), and big sagebrush (*A. tridentata*). The climate, topography, and vegetation of the area were described by Knowles (1982).

Black-tailed prairie dog towns, which occupy about 1.6% of the study area, are typically located on level upland sites and are considered by Knowles et al. (1982) to represent a distinct habitat type. Prickly pear, fringed sage, blue grama, western wheatgrass, and a variety of forbs prevail, and are interspersed with areas of erosion pavement.

Mountain Plover nests were studied on 9 major upland prairie dog towns on the north side of the Missouri River: Antelope Reservoir, Duck Lake, Many Deer, Robinson Cow Camp, Well Reservoir, Abu, Manning Corral North, Manning Corral South, and Dead Calf South. The towns ranged in size from 6 ha to 307 ha, and all were grazed by cattle under a 4-year rest-rotation grazing system.

Methods

Field work was conducted from 8 April to 1 September 1982. Nest sites were flagged after nests hatched, or were abandoned or destroyed, and data collection was delayed until all nests were terminated to prevent disturbing nests. Vegetation changes that occurred between nest initiation and nest site measurement were assumed to be similar for all nest and random plots. Vegetation within a 1 m^2 frame was measured at each nest site. In addition, for each nest site, vegetation at 10 random plots on the prairie dog towns, and 10 random plots in areas adjacent to towns, was similarly measured. Prairie dog town borders were usually well defined by an abrupt vegetation change; adjacent plots were outside the dog town, on level, grazed areas. Any plots that fell on steep-sided juniper slopes were discarded. The 3 groups to be compared were therefore defined as nest plots, town plots, and adjacent plots. The nest scrape, or the random point, was plot center. The plot variables measured or estimated were: 1) percent grass cover, 2) percent total plant cover, 3) prickly pear density, 4) big sagebrush density, 5) fringed sage density, 6) forb density, 7) mean vegetation height (cm), 8) rock (>8cm diameter) density, 9) percent litter-hummock cover (including the windblown lichen _Parmelia_ spp. and the low mat-forming _Phlox hoodii_), and 10) percent erosion pavement cover. Distance to the nearest prairie dog burrow or nearest rock over 8 cm in diameter was recorded if within 10 m.

Data were collected, beginning on 12 July, for the 26 nest plots, for 260 random town plots, and 260 random adjacent plots. Each variable within the 10 random town plots, and adjacent plots, was averaged for each nest plot, resulting in a sample size of 26 for each of the 10 variables for all groups.

In an effort to control experiment-wide error rate, a One-way Multivariate Analysis of Variance was attempted, but the assumption of homogeneous variance-covariance matrices was not met. Therefore, a Kruskal-Wallis nonparametric Analysis of Variance was run for each variable to test the hypothesis of equal distributions between the 3 groups. When variables were significantly different between the groups, _a priori_ tests were run to determine where the difference occurred.

Results

Twenty-six nests were found between 2 May and 10 July 1982 on 9 prairie dog towns. Variable means differed between the 3 groups (Table 2). The most striking differences between nest plots and town plots occurred with erosion pavement cover and forb density. Erosion pavement cover was greater on town plots than at nest plots, and forb density was greater at the nest plots. Mean values for total plant cover, grass cover, mean vegetation height, and prickly pear density were considerably greater in adjacent plots than at the nest or the town plots, whereas fringed sage density and forb density were both greater at the nest plot than on either the town or adjacent plots.

The Kruskal-Wallis test indicated that all variables except rock density and forb density were significantly different ($P \leq 0.05$) between the 3 groups (Table 3); these 2 were removed from further analysis. Of the remaining 8 variables, only erosion pavement cover and mean vegetation height differed significantly between nest plots and town plots; both were less at the nest plots than the town plots. When nest plots were compared to adjacent plots, only erosion pavement cover was not significantly different. Total plant cover, grass cover, big sagebrush cover, prickly pear cover, and mean vegetation height were all significantly greater in adjacent plots than at nest plots; fringed sage density and litter cover were significantly greater at the nest plot. No significant difference was found in distance to nearest prairie dog burrow between nest and town plots; mean distance was 7.3 m (SD=3.7) from the nest plot and 6.8 m (SD=4.2) from the town plot. Thirty-one percent of the nest plots had at least 1 rock present in the

Table 2. Characteristics of Mountain Plover nest plots, prairie dog town plots, and adjacent plots on the C. M. Russell National Wildlife Refuge.

Variable	Nest Plots (N = 26)		Dog Town Plots (N = 26)		Adjacent Plots (N = 26)	
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
% TOTAL PLANT COVER	38.65	14.39	32.77	10.60	50.23	10.29
% EROSION PAVEMENT	26.92	16.74	42.54	10.29	28.62	9.50
% GRASS COVER	14.54	15.66	14.50	11.28	32.23	12.62
ROCK DENSITY	0.77	1.50	0.23	0.43	0.38	0.57
BIG SAGEBRUSH DENSITY	0.04	0.19	0.27	0.67	1.04	1.18
FRINGED SAGE DENSITY	15.23	12.04	10.92	5.47	3.46	2.14
FORB DENSITY	42.27	45.99	25.15	27.39	15.04	6.76
% LITTER COVER	31.73	16.55	24.69	9.72	20.77	6.15
PRICKLY PEAR DENSITY	0.96	2.79	0.85	1.49	2.31	1.95
$\bar{X}$ VEGETATION HEIGHT (cm)	4.35	1.09	6.35	2.02	16.81	3.95

Table 3. P-values associated with test of hypotheses of equal group distributions for Mountain Plover nest plots, prairie dog town plots, and adjacent plots.

Variable	All Groups	Nests vs Dog Town Plots	Nests vs Adjacent Plots
% TOTAL PLANT COVER	0.000	0.149	0.002
% EROSION PAVEMENT	0.000	0.001	0.296
GRASS COVER	0.000	0.539	0.000
ROCK DENSITY	0.569		
BIG SAGEBRUSH DENSITY	0.000	0.083	0.000
FRINGED SAGE DENSITY	0.000	0.230	0.000
FORB DENSITY	0.109		
% LITTER COVER	0.047	0.142	0.016
PRICKLY PEAR DENSITY	0.000	0.302	0.000
$\bar{X}$ VEGETATION HEIGHT (cm)	0.000	0.000	0.000

a Kruskal-Wallis Test: Nests Plots = Prairie Dog Town Plots = Adjacent Plots.

b Mann-Whitney Test: Nest Plots = Prairie Dog Town Plots.

c Mann-Whitney Test: Nest Plots = Adjacent Plots.

plot, and the nearest rock was a mean distance of 8.5 cm (SD=9.4) from the nest. Of the 13% of town plots with rocks present, the nearest rock was an average of 26 cm (SD=17.8) from plot center, and 18% of the adjacent plots had rocks at a mean distance of 28 cm (SD=16.0).

Discussion

Habitat found in prairie dog towns appears to be necessary for Mountain Plovers to breed on the CMR, which has not been noted elsewhere for this species. Considerable vegetative variation occurred within prairie dog towns, depending in part upon prairie dog density and the intensity of grazing by cattle. Compared to surrounding areas, towns had more litter cover, bare areas, and fringed sage, generally found in a heterogeneous mixture. Characteristics of Mountain Plover nest sites appeared to differ little from overall town characteristics, except for shorter vegetation and less erosion pavement. Mountain Plovers apparently did not select bare areas for nest sites per se; percent erosion pavement at the nest site was comparable to that in adjacent areas, considerably less than is found on the dog towns. The slightly greater amount of litter at the nest site may be due partly to the presence of nest lining materials in and around the nest scrape. Although forbs and fringed sage were not found in significantly greater densities at the nest sites than on the towns in general, 21 nests were placed close (less than 10 cm) to a clump of fringed sage or forbs which was never high or dense enough to conceal the incubating bird. In 7 cases, nests were placed beside or close to large, flat rocks. The tendency to nest by a conspicuous object is a noted tendency in

Charadriidae species (Graul 1975). Allen (1980) found that incubating Long-billed Curlews (Numenius americanus) selected sites near objects such as manure piles, rocks, or bare dirt mounds. This may function to make the bird less conspicuous in areas with scant vegetation. Nest sites in general could not be distinguished from prairie dog town plots, except for the overall shorter vegetation and less erosion pavement at the nest sites.

The most striking differences between prairie dog towns and adjacent areas are decreased vegetative height in towns compared to adjacent areas and differences in plant species composition (Koford 1958, Bonham and Lerwick 1976, Hansen and Gold 1977, and O'Meilia 1980). Features that distinguish prairie dog town habitat from surrounding areas are decreased overall cover, big sagebrush density, grass cover, and increased bare areas and fringed sage. Knowles (1982) found significantly greater horizontal visibility in towns than in adjacent areas. One or more of these features may account for the suitability of dog towns as Mountain Plover habitat. Mountain Plovers evolved on short-grass prairie of the western Great Plains, and therefore select short vegetation for breeding areas. All townsites on the CMR occur within shrub-grassland or grassland habitats, and on the Western Unit, nearly all towns containing breeding plovers are found within the big sagebrush-blue grama habitat type (Knowles 1982). Prairie dog towns appear to be "islands" of suitable habitat within an area not otherwise suited for Mountain Plovers.

Prairie dog activities alter vegetative composition in a town over time (Koford 1958, Bonham and Lerwick 1976, Hansen and Gold 1977, Knowles 1982). The most noticeable changes are in increased plant diversity on towns, and selection against tall plants and shrub species by continuous clipping, which creates a low vegetation profile with many bare areas. I noted that big sagebrush was absent from towns or, if present, occurred in a stunted and defoliated condition. Species like western wheatgrass and big sagebrush are selectively over-clipped, favoring buffalo grass (Buchloe dactyloides), blue grama, and low-growing annual or perennial forbs (Koford 1958). However, prairie dog effects alone are difficult to assess because prairie dogs in most cases are closely tied to, or even dependent upon, grazing by cattle (Koford 1958, Hansen and Gold 1977, Knowles 1982). Cattle, together with prairie dogs, cause heavy use of areas, and by late summer, very little vegetation remains on the towns. Knowles (1982) believes that cattle use as much as two-thirds of the available forage on a town, possibly because of the high protein content of forbs that are present (O'Meilia 1980). Cattle congregate around reservoirs that are found in most prairie dog towns on the CMR, and appear to avoid areas with much slope. Sites that are topographically favorable for prairie dogs appear to be favorable for cattle also. Hansen and Gold (1977) reported that, except in short-grass prairie, heavy cattle use of an area was necessary for the establishment of prairie dog towns. On the mixed-grass prairies of the CMR, Knowles (1982) found that predation prevented prairie dogs from becoming established except in heavily grazed or disturbed sites, and that they cannot usually be maintained without the influence of cattle.

Mountain Plovers appear to select for a low vegetative profile not only for nesting but for all activities during the breeding season. Birds could not be driven from the towns. If flushed, they would always land on the town, a behavior also noted by Knowles et al. (1982).

Prairie dog towns enhance habitat suitability for a variety of species as well as provide diversity to the prairie. Hansen and Gold (1977) called prairie dog towns important ecosystem regulators, because they increase plant and animal diversity, disturb the soil, and affect primary productivity. Koford (1958) believed that habitat is improved for animals benefitted by burrows, bare areas, short vegetation and many forbs, and found that prairie dog activities may favorably affect the habitat of less common birds like McCown's Longspur (_Calcarius mccownii_) and Burrowing Owl (_Athene cunicularia_). O'Meilia (1980) found that numbers of small mammals were consistently greater where prairie dogs occurred than on areas where only cattle grazing occurred. Prairie dog towns may provide increased forage for native ungulates and provide increased prey items. In Montana, Knowles (1982) believed that prairie dog towns provide crucial breeding habitat for the Mountain Plover and the Burrowing Owl, both with limited and diminished distribution in the state. Since prairie dog control on the CMR stopped in 1964, Knowles (1982) recorded a 614% increase in town acreage, but most towns have nearly reached their maximum size and topography, or soil type will apparently prevent further expansion. Maintaining these towns is crucial to maintain breeding Mountain Plovers on the CMR. Widespread prairie dog control off of the CMR may further limit suitable breeding habitat for Mountain Plovers in Montana.

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CHAPTER IV

INSECT ABUNDANCE AND SPECIES DIVERSITY ON AND OFF OF A PRAIRIE DOG TOWN

Mountain Plovers (*Charadrius montanus*) on the Charles M. Russell National Wildlife Refuge (CMR) in northcentral Montana selectively use black-tailed prairie dog (*Cynomys ludovicianus*) towns for breeding, nesting, and feeding (Knowles et al. 1982). Except for the above paper and other brief reports of Mountain Plovers occurring on prairie dog towns elsewhere (Cameron 1907, Walker 1955, Peart 1980, Campbell and Clark 1981), this association has not been investigated. On the major portion of its breeding range, the Mountain Plover is found on level, heavily grazed sites with sparse, short vegetation. Several possible reasons exist for the selective use of prairie dog towns on the CMR. Dog towns may offer favorable habitat in terms of plant species composition, vegetative height and structure, topography, food availability, or a combination thereof. Mountain Plovers are insectivorous (Bent 1929, Storer 1941, Goodrich 1945:195, Laun 1957, Baldwin 1971, Graul 1976), and therefore insect abundance and species diversity were of interest in areas where the birds occurred. Bent (1929) and Baldwin (1971) found that ground-dwelling beetles, grasshoppers, crickets, and ants were primary food items of the Mountain

Plover. This paper compares availability of insects on a prairie dog town occupied by Mountain Plovers, and on areas adjacent to the town.

Pitfall traps are designed to sample surface-dwelling insects, and were used for this study to sample insect populations. Although various limitations and biases are inherent to this trapping system (Greenslade 1964, Hayes 1970), pitfall trapping can offer useful guides to distribution and abundance of insect populations, especially in areas with little vegetative cover (Mitchell 1963). Objectives of this study were to determine differences between insect abundance and species diversity for on- and off-town sites, with special emphasis placed on ground-dwelling insects, and to determine whether insect abundance or diversity varies between on-town sites during the breeding season.

STUDY AREA

The study area is located in northcentral Montana within the Western Unit of the CMR, comprising 560 km^2 on the north side of the Missouri River. The area is in Phillips County, approximately 100 km northeast of Lewistown and 100 km southeast of Malta.

Black-tailed prairie dog towns typically occur on broad, level ridgetops, which run primarily north-south and become continuous rolling prairie near the northern boundary of the Refuge. Prairie dog towns are considered by Knowles et al. (1982) to represent a distinct habitat type, and occupy about 1.6% of the study area.

I confined insect trapping to Antelope Town, one of my principal study towns, which contained 12 to 16 breeding Mountain Plovers. Antelope, a town of 101 ha, included 2 stock watering ponds and was grazed by cattle beginning on 7 July 1982. Slope in the town did not exceed 12%. Most vegetation on the town was shorter than 10 cm, although 7 to 10 ha were dominated by big sagebrush (Artemisia tridentata), which grew as high as 40-50 cm. Otherwise, prickly pear (Opuntia polyacantha), fringed sage (Artemisia frigida), blue grama (Bouteloua gracilis), western wheatgrass (Agropyron smithii), and a variety of forbs prevailed, interspersed with areas of erosion pavement. Similar vegetation occurred in areas adjacent to the town, but vegetative height was commonly 40-60 cm, with more big sagebrush and western wheatgrass and less fringed sage and erosion pavement than on the town.

METHODS

Insects were captured in pitfall traps described by Greenslade (1964). One hundred traps were randomly located at Antelope Town (50 on the town and 50 in adjacent, level, grazed areas). Traps were left open for 8 consecutive days and nights during each collection; insects were removed on the eighth day. The traps were then closed until the next collection began. Four insect collections were completed in 1982, on 17 May, 23 June, 15 July, and 10 August. In addition to pitfall trapping, I attempted sweepnet transects, but this method proved to be inadequate for on-town sampling because of the lack of vegetation throughout most of the town. Insect samples were first separated by species, and then grouped by order. Shannon's Index of general diversity (Pielou 1977:299) was used to compare species structure between collections, and between on- and off-town areas within collections.

RESULTS

Pitfall trapping is an effective way to capture ground-dwelling insects, but is inadequate for capturing grasshoppers and most other hopping or flying insects. Although I found grasshoppers in my traps, I did not feel that the sample was representative of their numbers compared to other insects. I included grasshoppers and crickets together to give a comparative idea of Mountain Plover food items as they occurred on- and off-town.

Cattle damage to pitfall traps was minimal during the collections, but some prairie dog damage occurred, primarily in 2 attempts by dogs to bury open traps during the third collection. A total of 4,534 insects were collected, representing 9 orders; best represented were Hymenoptera at 42.9% (almost entirely ants), Coleoptera, 24.7%, primarily Scarabidae (dung beetles), Carabidae (ground beetles), and Tenebrionidae (darkling beetles), and finally Orthoptera, 6.7% of the total, consisting of Gryllidae (crickets), Tettigoniidae (long-horned grasshoppers), and Acrididae (short-horned grasshoppers). In addition, spiders accounted for 12.6% of the total sample. Other insect categories were either of little importance as Mountain Plover food items, or they occurred in negligible amounts. Insect numbers averaged 12.8 (SD=13.6) per trap on-town and 11.5 (SD=7.8) per trap off-town. Insect diversity was greater off-town than on-town for 3 of the 4 collections, although values fell within a narrow range (Fig. 2). Means were calculated for several variables for on- and off-town locations per collection. Mean insect totals and species number per trap were similar for on-town and off-town samples for all 4 collections (Fig. 3), and species number was greater off-town for all collections but the first. Mean values for ants and coleopterans were slightly higher for on-town samples, whereas orthopteran values, although low, were consistently higher for off-town samples (Fig. 4).

Mann Whitney U tests were run to test the hypothesis of no difference between on- and off-town areas. When all collections were pooled, only coleopterans were found to be significantly ($P=0.013$) greater on-town than off-town. On-town and off-town traps were compared within collections for each variable; number of species per trap was significantly greater ($P=0.015$) off-town than on-town for collection 2, and total insects per trap were significantly greater ($P=0.049$) off-town than on-town for collection 3. To test for differences between collections for on-town samples only, a Wilcoxon Matched Pairs test was run, which compared variables from 2 collections at a time, 1 with 2, 2 with 3, and 3 with 4, with the pitfall traps being the matched pairs. Collection 1 paired with 2, and 3 paired with 4 yielded no significant differences, but when 2 was paired with 3, ants, number of species per trap, and total insects were all significantly greater for collection 3. This reflects to a large degree the marked increase in ants that occurred between the second and third collection.

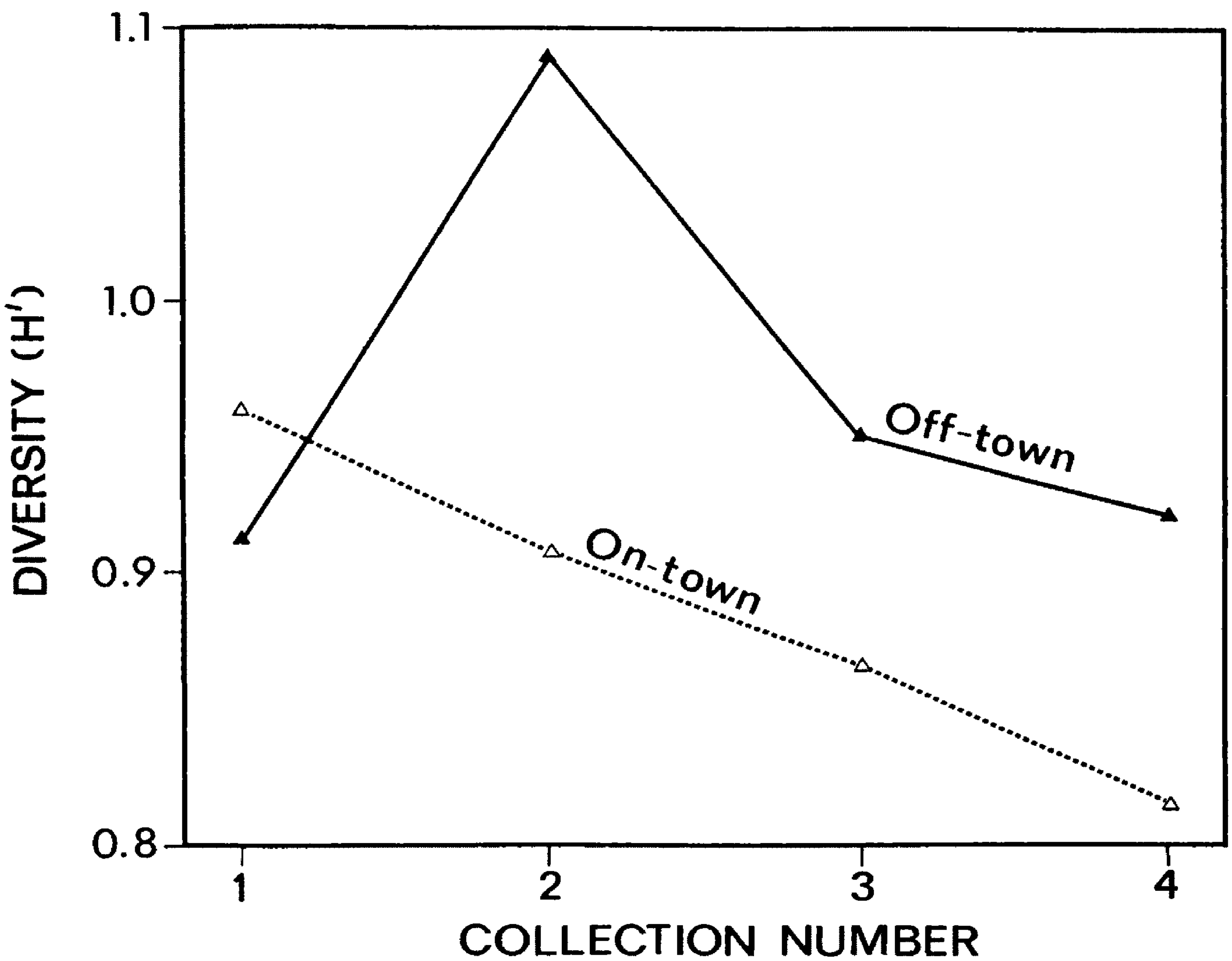

Fig. 2. Insect diversity (H′) for on- and off-prairie dog town sites during four collections at Antelope Town, 1982.

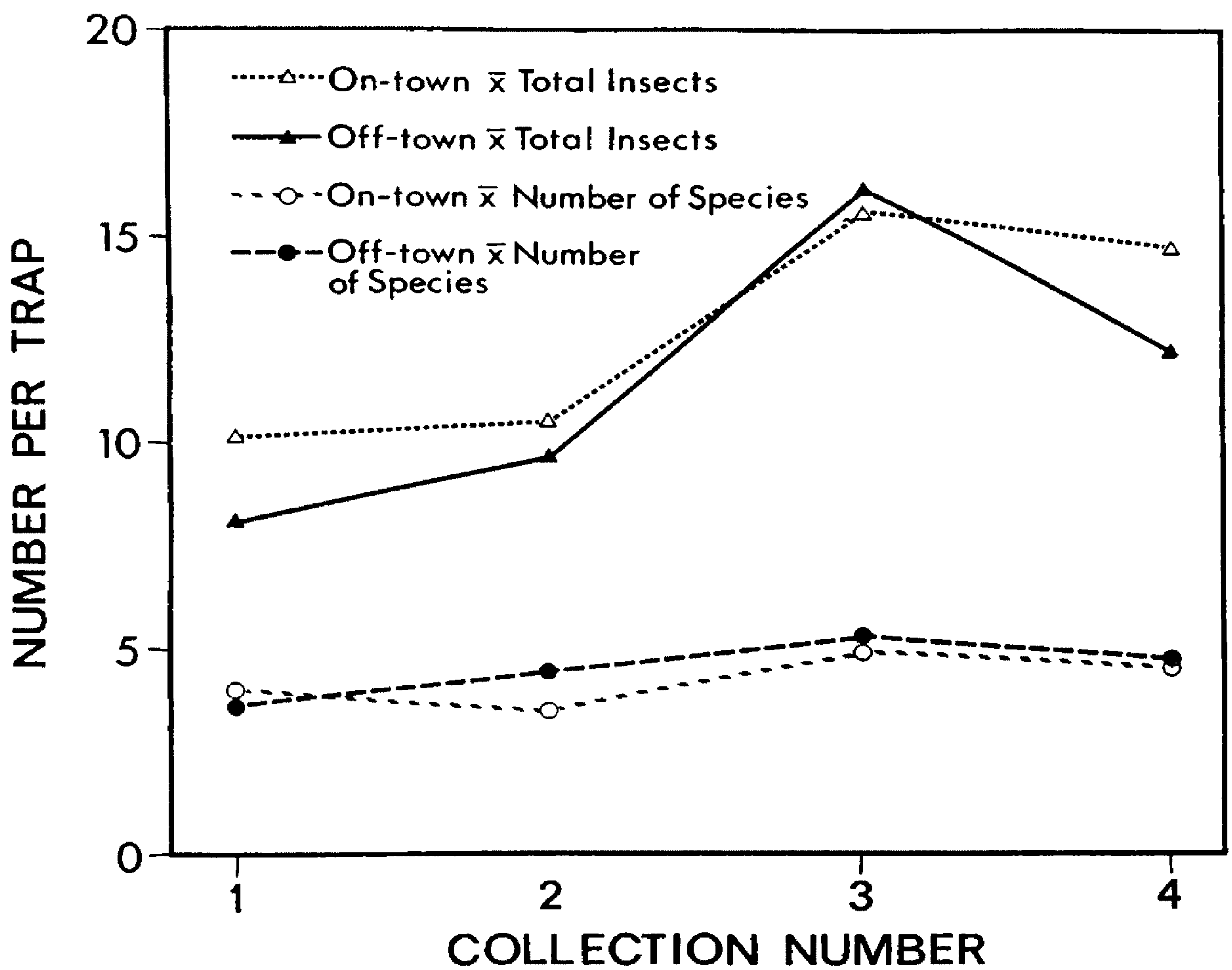

Fig. 3. Mean total insects and mean number of species per trap for on- and off-prairie dog town sites during four collections at Antelope Town, 1982.

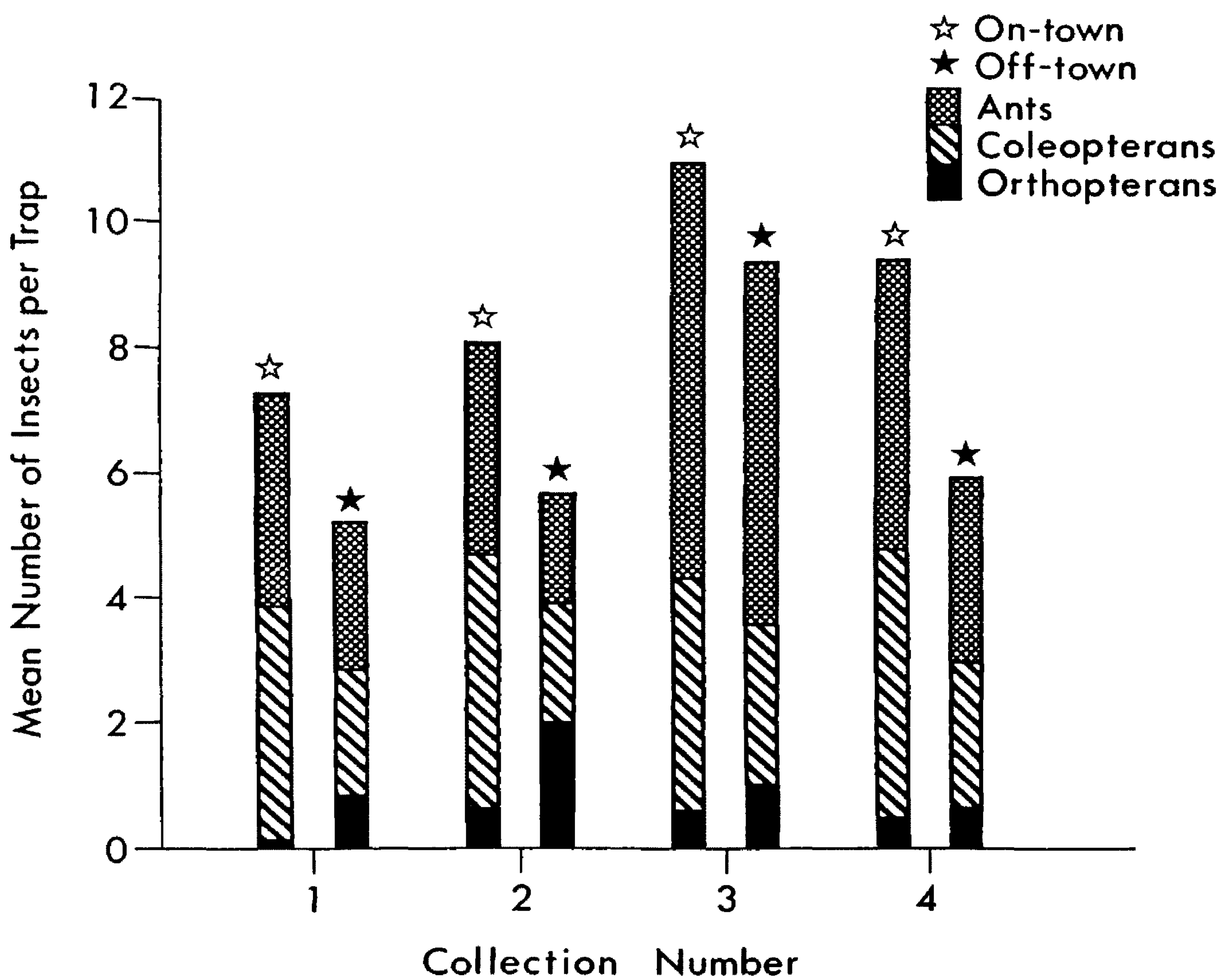

Fig. 4. Mean number of ants, coleopterans and orthopterans per trap for on- and off-prairie dog town sites during four collections at Antelope Town, 1982.

DISCUSSION

In general, results from pitfall trapping revealed very little difference in insect samples on and off of a prairie dog town. I assumed that biases inherent to the trapping method were equal for on- and off-town sites. Ground-dwelling insects in general tended to be slightly more numerous on-town, but species diversity was greater off-town. Similar results were reported from studies on heavily grazed areas compared to ungrazed areas (Smith 1940). Ants and ground-dwelling coleopterans, which are both preferred Mountain Plover food items (Bent 1929 and Baldwin 1971) were more numerous on-town than off throughout the study, but coleopterans did not exhibit the marked increase in abundance that ants did. This increase in ants during late June and July coincided with chick emergence and growth. Baldwin (1971) found that 14% of the juvenile diet was comprised of ants, compared to 2% for adults. For both age classes, Baldwin noted that ground-dwelling beetles were the most important food item, comprising 68% of the adult diet, and 53% of the juvenile diet. Crickets and grasshoppers together represented approximately 19% of both adult and juvenile diets. Although my pitfall trapping method did not adequately sample grasshoppers, several studies based on sweepnet samples found grasshoppers were more abundant in areas with less vegetation. About 4 times as many insects, primarily grasshoppers, occurred in a heavily grazed area compared to an ungrazed pasture (Weese 1938). Coleopterans were also more numerous in samples from overgrazed areas. Weese felt that bare areas were advantageous for insect breeding, and that grazing kept plants at an earlier phenological stage, which was more favorable to insect foraging. Grasshoppers showed a preference for overgrazed habitat, but coleopterans decreased with overgrazing (Smith 1940). Koford (1958) felt that prairie dog activities created favorable habitats for insects, primarily grasshoppers, which benefitted by bare areas and increased forbs; the presence of burrows was also favorable for ground-dwelling beetles.

Spiders were not included in analyses although they occurred in 64% of the on-town and 76% of the off-town traps. I do not believe that this reflects relative spider abundance; in most cases spiders inhabited the traps rather than being captured by them. I assumed that effects of this spider colonization were more or less equal for on- and off-town traps.

Results indicate that more insects of importance as food items to the Mountain Plover occur on Antelope town than off of it. However, prey abundance is but 1 factor in prey availability; prey vulnerability is also important. Mountain Plovers occur on sites with short sparse vegetation throughout their range and appear to be well adapted to ground foraging in areas with little vegetation. They seldom fly, but move rapidly in search and pursuit of prey which is usually found on the ground surface. Prairie dog towns on the CMR are areas of short vegetation within a shrub-grassland habitat characterized by big sagebrush (Knowles 1982). Mountain Plovers appear to have a narrow range of habitat specificity (Rotenberry and Wiens 1980), and Graul (1980) considered them to be a stenotopic species. Physical structure of habitat is considered to be a primary proximate factor in avian habitat selection because it may provide indirect cues to potential prey availablity and diversity (Wiens 1969). Prairie dog towns apparently met Mountain Plover habitat requirements that were not met by the surrounding areas, and foraging efficiency may be one of the reasons. Other factors are probably involved in habitat selection, since the physical structure of habitat also provides shelter, nesting substrate, and protection from predators (Rotenberry 1981).

Graul (1973, 1976) noted extreme fluctuation in insect populations, particularly short-horned grasshoppers, on the short-grass prairie in response to precipitation levels and felt that Mountain Plovers respond to high food levels by producing multiple clutches. Wiens (1973, 1977) theorized that the energy flux through avian consumers in grasslands was very small overall, and suggested that grassland bird populations probably play a minor role in reducing biomass of invertebrates throughout the breeding season, and may exist on "excesses" of production. Food resources are seldom in short supply in grassland habitats (Wiens 1977, Wiens and Rotenberry 1979), and Rotenberry (1980) hypothesized that climatic variability serves to prevent avian population levels from rising to the point where resources are limited, even though the food resource is often superabundant. I suspect that the low breeding density of Mountain Plovers on the CMR is a response to a limited habitat availability in the form of prairie dog towns rather than a limited food resource. More work needs to be done on all aspects of this species' habitat requirements in light of the limited distribution of the Mountain Plover over most of its former range, and the uncertain future of the prairie dog towns that now support it on the CMR.

Inherent problems exist when sampling insect populations: procedures used by entomologists are not the same as those used by birds, and insects may not be adequately sampled but may be sought out by many birds (Wiens 1977). Large beetles and orthopterans in particular avoid traps better than they avoid birds. Rotenberry (1980) cautions about potential problems in "one-shot" studies, whatever the relationship examined. Because of the extreme climatic fluctuations on the short-grass prairie and ecological differences between towns, I suspect that substantial variation would arise if sampling were replicated over time or between towns.

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CHAPTER V

ACTIVITY PATTERNS OF THE MOUNTAIN PLOVER ON THE CHARLES M. RUSSELL NATIONAL WILDLIFE REFUGE

Mountain Plovers (Charadrius montanus) in Montana are near the northern edge of their breeding range, and the major population is found on the Charles M. Russell National Wildlife Refuge (CMR). Mountain Plovers in this area are associated with black-tailed prairie dog (Cynomys ludovicianus) towns, and they remain on the dog towns throughout the breeding season to feed, nest, and rear young (Knowles et al. 1982). The Mountain Plover was designated as a species of "special interest or concern" in Montana (Flath 1979) because of reduced populations throughout its range, and its uncertain status within the state. Habitat loss caused by widespread conversion of short-grass prairie to agricultural land is thought to be the primary reason for the decline (Cooke 1915, Jurek 1973, Lock 1975, Wiens and Dyer 1975, Graul 1980, Watts and Eichhorn 1981), but Knowles et al. (1982) suggested that extensive prairie dog control may have been important in Montana.

Ecological and behavioral studies of breeding Mountain Plovers were conducted by Laun (1957) in southeastern Wyoming and by Graul (1975) in northeastern Colorado, areas that are believed to contain the highest remaining breeding populations. Anecdotal reports, primarily from

Colorado, described some aspects of Mountain Plover behavior and breeding biology (Coues 1878, Bradbury 1918, Bent 1929, Bailey and Niedrach 1933, Walker 1955). Knowles et al. (1982) account of the Mountain Plover's selective use of prairie dog towns is the only published ecological study from Montana.

This study investigates Mountain Plover activities throughout their breeding season, as they relate to breeding phase, temperature, and time of day.

Study Area

The study area covers 560 km^2 and is located in northcentral Montana, within the Western Unit of the CMR, on the north side of the Missouri River. The area, in Phillips County, is approximately 100 km northeast of Lewistown and 100 km southwest of Malta.

The area is characterized by rough, timbered, eroded breaks of the Missouri River. Steep-sided ridges alternate with deep-cut coulees, running parallel north-south, from productive riverbottoms in the south to a high plateau in the north. Major ridgetops flatten and broaden progressively to form rolling prairie toward the northern boundary of the Refuge. The area is well-roaded and easily accessible by vehicle during dry weather.

Ponderosa pine (*Pinus ponderosa*), together with Rocky Mountain juniper (*Juniperus scopulorum*) thickets, dominate north-facing slopes. The principal plant species found on the broad ridgetops are western wheatgrass (*Agropyron smithii*), blue grama (*Bouteloua gracilis*), prickly pear (*Opuntia polyacantha*), fringed sage (*Artemisia frigida*) and big sagebrush (*A. tridentata*). Knowles (1982) described the climate, topography, and vegetation of the area.

Black-tailed prairie dog towns, which occupy about 1.6% of the study area, are typically located on upland level sites and are considered by Knowles et al. (1982) to represent a distinct habitat type. Prickly pear, fringed sage, blue grama, western wheatgrass, and a variety of forbs prevail, interspersed with areas of erosion pavement.

Mountain Plover observations were made on 12 upland prairie dog towns that ranged in size from 6 ha to 307 ha. All contained stock watering ponds and all were grazed by cattle on a 4-year rest-rotation grazing system during the 2 years of my study.

Methods

During my 1982 field season, I sampled Mountain Plover behavior on prairie dog towns within my primary study area. I combined Altmann's (1974) Focal Individual and Instantaneous Sampling techniques to systematically sample behavior and thereby determine the percent of time that birds devoted to various activities. I chose to use 30-minute observation periods, so that the instantaneous behavioral event was recorded at the beginning of each of 30 1-minute intervals for every observational period. When observing a flock, I selected 1 focal individual, usually the closest bird, and observed it throughout the period. Number of birds present during each observation period was recorded. Sex cannot be determined in the field, so birds were identified only as adults or fledged juveniles. Visibility was generally excellent, and unless the birds flew to a distant area, I was able to continually observe 1 individual for the 30-minute period. I divided the study season into 3 phases: prenesting, nesting, and postnesting, and all observations were included in 1 of the 3 phases. Observations were taken at various times of the day between dawn and dusk throughout the season. Specific behavioral events were recorded for each sample, but because of low sample sizes, were later grouped into 4 categories: 1) courtship and aggressive displays, 2) maintenance activity (preening, and the active pursuit, capture, and ingesting of prey), 3) locomotion (flying, walking), and 4) inactivity (standing, resting, incubating). Behavior and vocalizations of the Mountain Plover were described in detail by Graul (1973, 1974). Percent of each category was calculated for each observation period, and percentages were averaged for each breeding phase. Observations were also broken down by temperature and time.

Results

The prenesting phase occurred from the beginning of April through 18 May. Birds nested from 19 May until 5 July, and post-nesting began 5 July; my last observation was on 17 August. Mean numbers of Mountain Plovers present during each observational period by phase were prenesting—1.8, nesting—1.3, and postnesting—4.6.

The 4 activity categories, when analyzed by phase, exhibited only slight differences (Fig. 5). Percent of inactivity increased throughout the season. Locomotion remained about the same from the first to the second phase, but decreased during the third. Maintenance activities remained relatively stable throughout the period, and courtship steadily

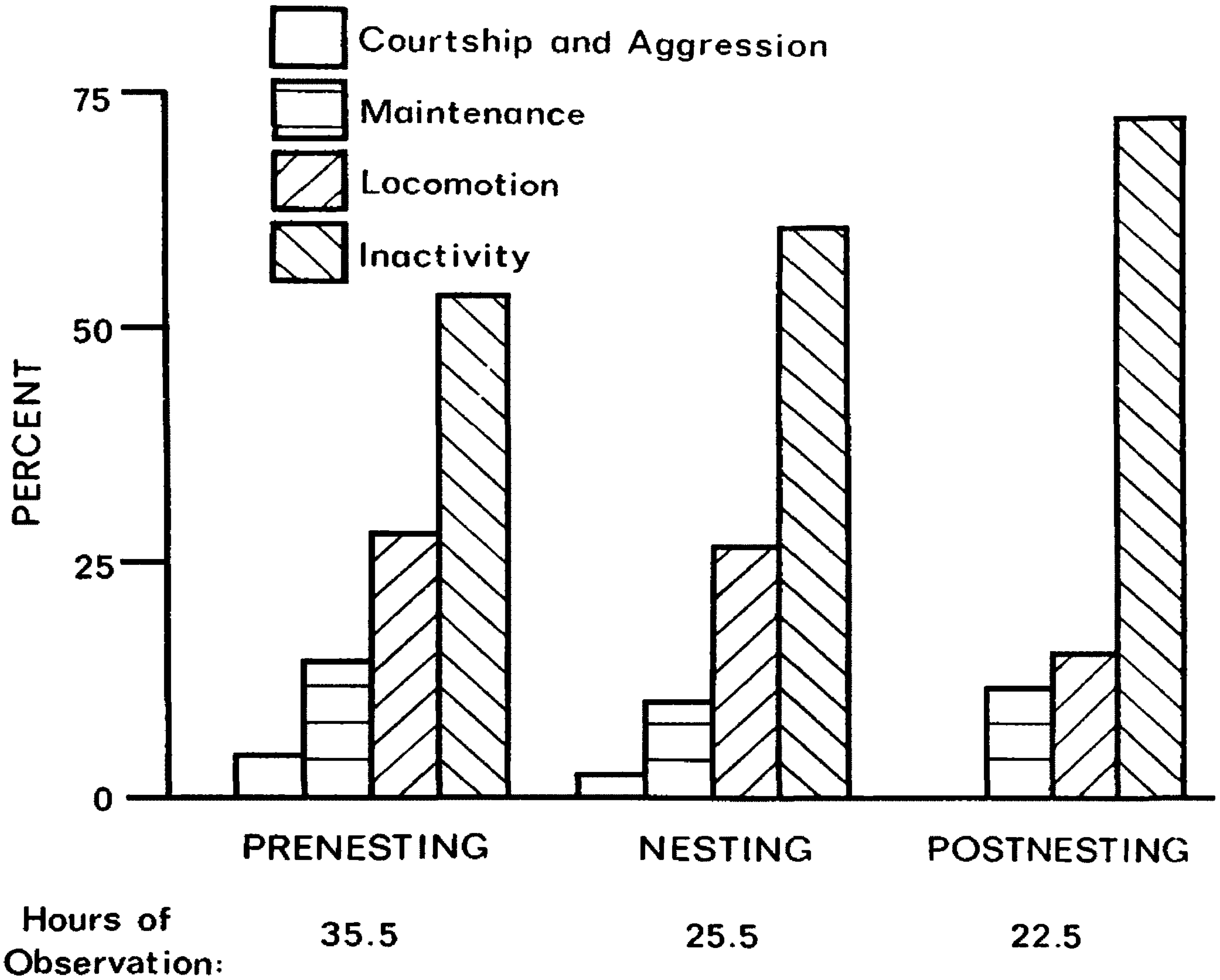

Fig. 5. Percentages of Mountain Plover activity by breeding phase, April through August, 1982.

declined. No courtship or aggressive activities were recorded during the third phase. Inactivity was consistantly the largest category, and by the third phase, it accounted for 70% of the total sample. Results were similar for activity levels grouped by temperature (Fig. 6), except that maintenance activities declined as temperatures increased. When activity levels were rated by time of day (Fig. 7), maintenance and locomotion were lowest and inactivity highest at midday, and courtship was lowest during the early part of the day.

Discussion

Mountain Plover activity levels appear to be related to season, time of day, and temperature. These factors are interrelated; temperature is cooler both early in the season, and early and late in the day. Mountain Plovers occur on short-grass prairies, nest on the ground, and bear the full intensity of the summer sun without benefit of shade or elevated perches. Temperatures on prairie dog towns were as high as 38° C in July. Mountain Plovers exhibited regulatory responses as summer heat increased; these included decreased activity during the heat of the day, panting, and elevating the feathers. Many animals can move among "patches" within their environment and remain in relatively optimal conditions (Ricklefs 1979:163), but Mountain Plovers must regulate their activity levels temporally and according to climatic conditions. Courtship activities increased with time of day, but decreased as the season progressed and heat increased. Allen (1980) noted that courtship displays for Long-billed Curlews (*Numenius americanus*) were more frequent during early morning hours. Graul (1975)

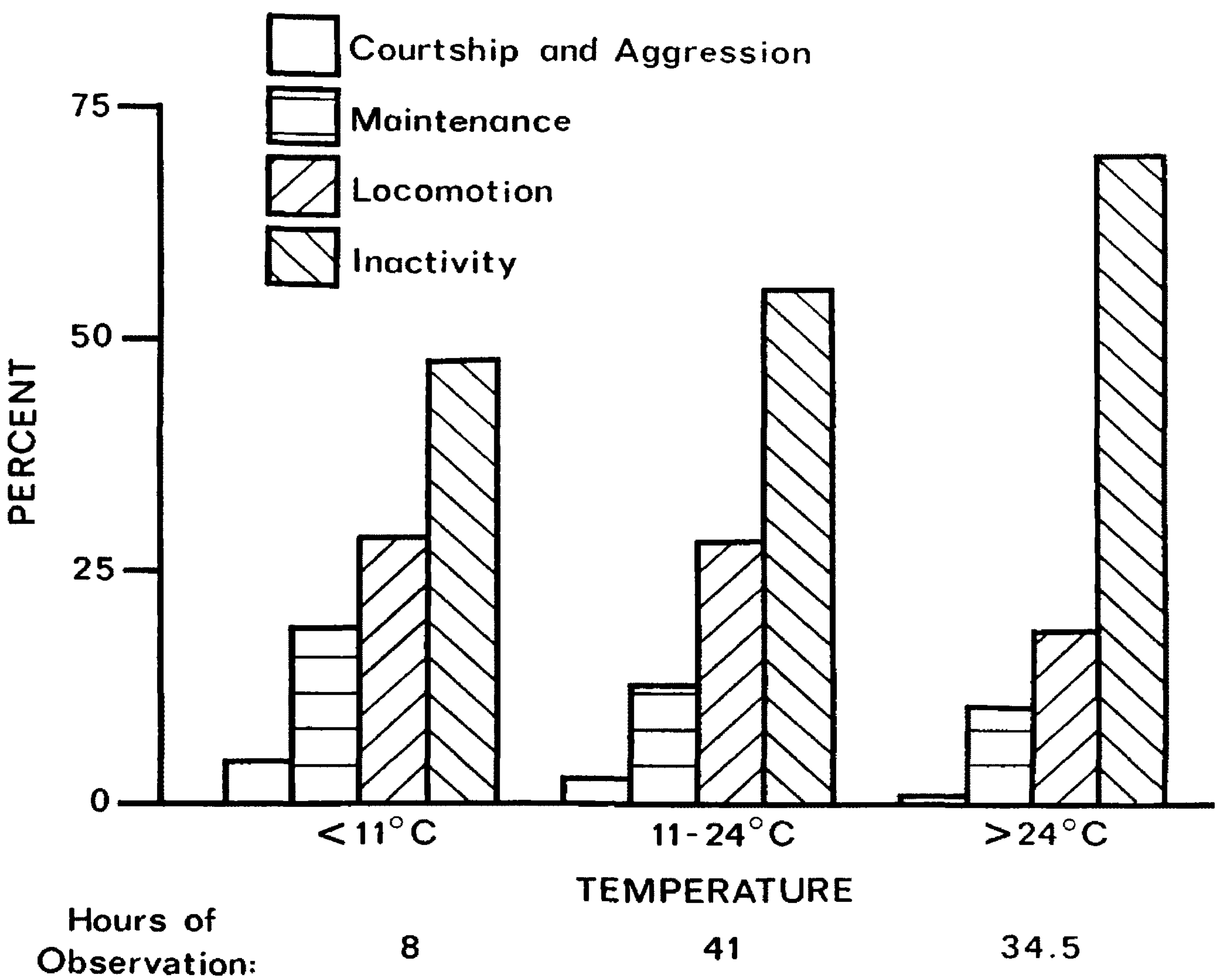

Fig. 6. Percentages of Mountain Plover activity by temperature, April through August, 1982.

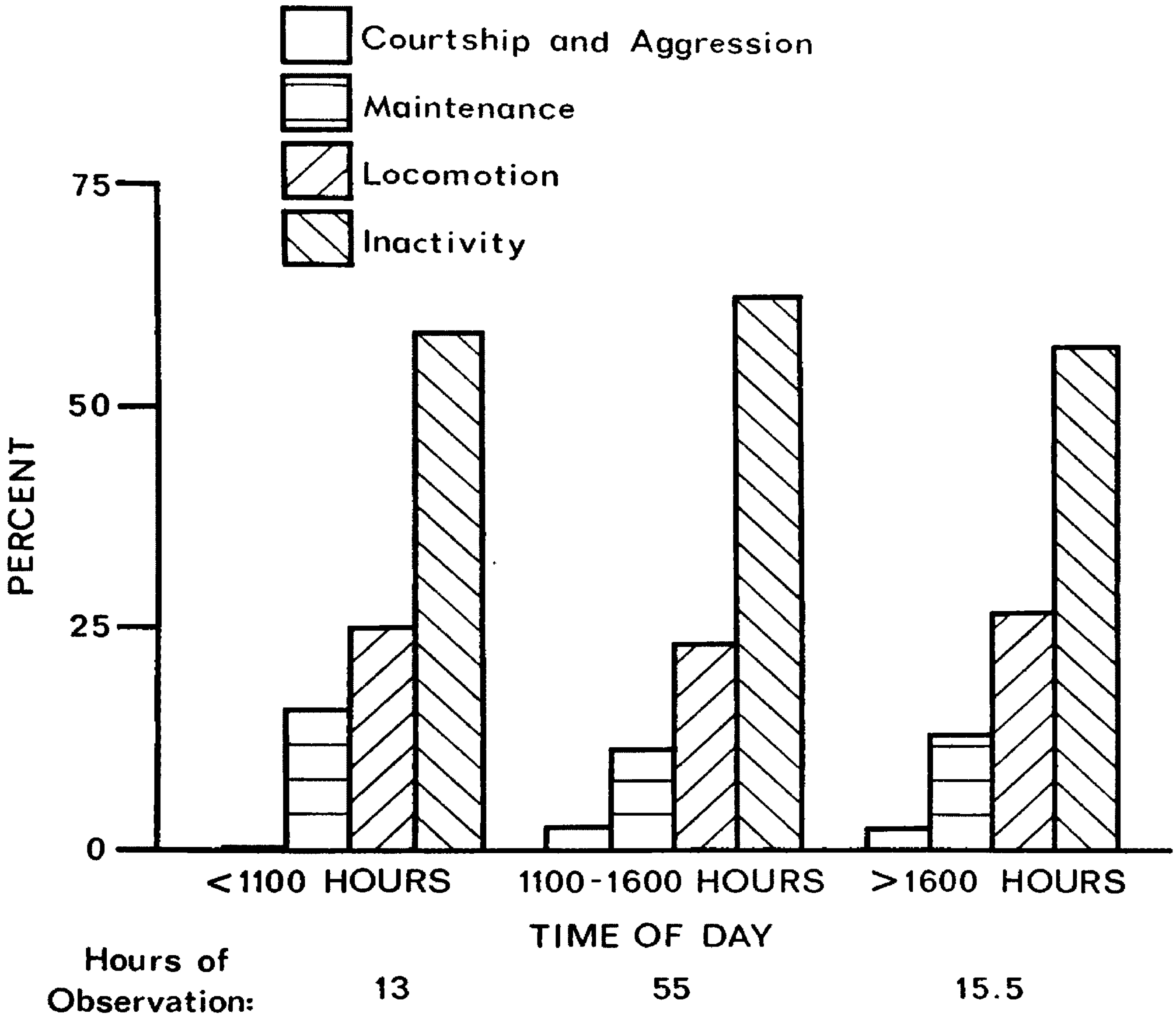

Fig. 7. Percentages of Mountain Plover activity by time of day, April through August, 1982.

felt that egg laying and incubation for the Mountain Plover was condensed to about a 60-day period to avoid nesting during the most hot and arid conditions of summer. He also noted that to reduce effects of aridity and heat, the birds were active during the early morning and late afternoon hours. Wiens (1974) also reported time limitations on breeding imposed by the relatively short period between beginning of food production in the spring and onset of high summer temperatures on the short-grass prairie. Slight differences in activity levels were noted by time of day, but differences were more noticeable when compared with increasing temperature. Inactivity steadily increased with increasing temperatures. These may be adaptations developed to cope with extreme temperatures.

Hutt and Hutt (1970) discussed several methods for recording behavior during time-sampling intervals, and contended that recording the instantaneous event at the beginning of each interval leads to over-representation of infrequent or rapidly-occurring events. The opposite seemed to be true of my observations. Mountain Plover activity was usually sporadic, rapid, and intense for short periods, interrupted with numerous pauses, which, with my sampling method, lead to an overestimation of inactivity. During any activity bout, many pauses were recorded as inactivity. This was particularly true of feeding activity, which was underestimated. The vast majority of behavior that occurred during a feeding bout was classified as standing or walking; the actual pursuit and capture of prey items happened relatively infrequently. Thus, my results are somewhat misleading, underestimating the amount of time Mountain Plovers spent feeding. The problem therefore lies not only with the sampling method but also with my classification of behavioral categories. For any future work, behavioral categories should be better defined so that all activities which occur within a specific behavior are included. Also, I believe that shorter intervals, perhaps 15 seconds rather than 1 minute, between behavior recordings may have yielded better results as well as increasing sample size. However, I believe that the general trends exhibited by the data are valid. The method of recording the behavioral event seemed the least subjective of those mentioned by Hutt and Hutt (1970), and may best represent behavior overall.

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APPENDIX A

Table 1. Mountain Plover nest histories, 1981 and 1982.

Nest Number	Number of Eggs	Prairie Dog Town	Date Found	Date Hatched	Number Hatched
1	3	Antelope	5/23/81	6/13/81	2
2	3	Many Deer	5/31/81	6/13/81	2
3	3	Well	6/2/81	6/17/81	3
4	3	Antelope	6/3/81	6/18/81	3
5	3	Many Deer	6/6/81	6/14/81	3a
6	3	Duck Lake	6/10/81	6/10/81	2
7	3	Manning N	6/12/81	6/28/81	3
8	3	Many Deer	6/21/81	6/27/81	3
9	3	Manning S	6/24/81	b	-
10	3	Manning N	6/24/81	6/24/81	3
11	3	Antelope	6/25/81	b	-
12	3	Manning N	6/27/81	6/27/81	3
13	3	Manning N	6/27/81	6/29/81	3
14	3	Duck Lake	5/2/82	c	-
15	3	Antelope	5/12/82	b	-
16	3	Antelope	5/16/82	d	-
17	3	Rob Cowcamp	5/21/82	c	-
18	3	Well	5/21/82	b	-
19	3	Antelope	5/22/82	e	-
20	3	Antelope	5/22/82	6/14/82	2
21	3	Abu	5/23/82	b	-
22	3	Manning N	5/25/82	6/22/82	3
23	2	Duck Lake	6/1/82	d	-
24	3	Antelope	6/1/82	6/20-22/82	3
25	2	Manning N	6/8/82	7/3-5/82	2
26	3	Manning N	6/9/82	6/24-25/82	3
27	3	Manning N	6/9/82	6/24-25/82	3
28	3	Dead Calf S	6/10/82	6/20-22/82	3
29	2	Manning S	6/11/82	7/5-9/82	2
30	3	Manning S	6/11/82	7/3-5/82	3

Table 1. Continued.

Nest Number	Number of Eggs	Prairie Dog Town	Date Found	Date Hatched	Number Hatched
31	3	Antelope	6/12/82	b	-
32	3	Antelope	6/12/82	7/6/82	3
33	3	Antelope	6/13/82	6/14/82	3
34	3	Many Deer	6/13/82	7/9/82	1
35	3	Many Deer	6/13/82	6/18-20/82	3
36	3	Many Deer	6/15/82	f	-
37	2	Antelope	6/26/82	7/7/82	2
38	3	Manning N	7/11/82	7/16-18/82	3
39	3	Manning S	7/11/82	7/16-18/82	3

a abandoned
b 1 dead chick at nest site
c 2 eggs missing, 3rd abandoned
d all eggs missing, predation assumed
e nest accidentally destroyed by observer
f 2 eggs destroyed

Appendix B

Mountain Plover Banding Summary

Bird Number	Date	Prairie Dog Town	Band Prefix	Band Number	Age	Weight (g)
1	240581	Many Deer	852	80703	Adult	.
2	60681	Antelope	852	80704	Adult	.
3	70681	Antelope	852	80705	Adult	.
4	70681	Many Deer	852	80706	Adult	.
5	70681	Many Deer	852	80707	Adult	.
6	70681	Well Res	852	80708	Adult	.
7	80681	Many Deer	852	80709	Chick	13
8	80681	Many Deer	852	80710	Chick	12
9	80681	Many Deer	852	80711	Chick	12
10	90681	Antelope	852	80712	Chick	13
11	90681	Antelope	852	80713	Chick	13
12	90681	Antelope	852	80714	Chick	12
13	100681	Well Res	852	80715	Chick	18
14	100681	Well Res	852	80716	Chick	16
15	100681	Duck Lake	852	80717	Chick	10
16	100681	Antelope	852	80718	Chick	13
17	110681	Abu	852	80719	Chick	12
18	110681	Abu	852	80720	Chick	11
19	110681	Abu	852	80721	Chick	12
20	110681	Abu	852	80722	Adult	.
21	120681	Well Res	852	80723	Chick	29
22	120681	Well Res	852	80724	Chick	22
23	120681	Dead Calf S	852	80725	Chick	13
24	150681	Many Deer	852	80726	Chick	11
25	150681	Many Deer	852	80727	Chick	11
26	150681	Antelope	852	80728	Chick	11
27	150681	Antelope	852	80729	Chick	11
28	160681	Dead Calf S	852	80730	Chick	12
29	160681	Dead Calf S	852	80731	Adult	.
30	200681	Antelope	852	80732	Chick	13
31	200681	Antelope	852	80733	Chick	14
32	200681	Antelope	852	80734	Chick	15

Appendix B continued.

Bird Number	Date	Prairie Dog Town	Band Prefix	Band Number	Age	Weight (g)
33	210681	Well Res	852	80735	Chick	19
34	210681	Well Res	852	80736	Chick	19
35	210681	Well Res	852	80737	Chick	20
36	210681	Many Deer	852	80738	Adult	.
37	220681	Rob Cowcamp	852	80739	Chick	19
38	220681	Rob Cowcamp	852	80740	Chick	24
39	240681	Mann C S	852	80741	Adult	.
40	240681	Mann C N	852	80742	Chick	10
41	240681	Dead Calf N	852	80743	Chick	18
42	240681	Mann C N	852	80744	Chick	18
43	240681	Dead Calf N	852	80745	Chick	19
44	250681	Antelope	852	80746	Chick	46
45	270681	Mann C N	852	80747	Adult	.
46	270681	Mann C N	852	80748	Adult	.
47	280681	Antelope	852	80749	Juvenile	56
48	280681	Well Res	852	80750	Juvenile	64
49	290681	Dead Calf S	852	80751	Juvenile	57
50	290681	Dead Calf N	852	80752	Chick	47
51	290681	Mann C S	852	80753	Chick	32
52	300681	Many Deer	852	80754	Chick	17
53	300681	Many Deer	852	80755	Chick	16
54	300681	Many Deer	852	80756	Chick	18
55	10781	Antelope	852	80757	Adult	.
56	10781	Well Res	852	80758	Juvenile	58
57	20781	Well Res	852	80759	Chick	39
58	20781	Antelope	852	80760	Juvenile	70
59	20781	Antelope	852	80761	Juvenile	62
60	50781	Mann C S	852	80762	Chick	44
61	60781	Mann C N	852	80763	Juvenile	61
62	70781	Mann C N	852	80764	Juvenile	72
63	80781	Abu	852	80765	Chick	43
64	80781	Mann C S	852	80766	Juvenile	64
65	130781	Abu	852	80767	Juvenile	55
66	150781	Buckskin	852	80768	Juvenile	72
67	150781	Buckskin	852	80769	Juvenile	61
68	150781	Buckskin	852	80770	Juvenile	57
69	160781	Rob Cowcamp	852	80771	Chick	13
70	160781	Rob Cowcamp	852	80772	Chick	14

Appendix B continued.

Bird Number	Date	Prairie Dog Town	Band Prefix	Band Number	Age	Weight (g)
71	160781	Rob Cowcamp	852	80773	Chick	15
72	160781	Rob Cowcamp	852	80774	Adult	85
73	200781	Mann C N	852	80775	Chick	47
74	200781	Mann C N	852	80776	Juvenile	57
75	200781	Mann C S	852	80777	Chick	18
76	200781	Mann C S	852	80778	Chick	41
77	210781	Mann C N	852	80779	Chick	38
78	210781	Mann C N	852	80780	Chick	22
79	210781	Mann C N	852	80781	Chick	15
80	270781	Mann C N	852	80782	Chick	13
81	270781	Mann C S	852	80783	Chick	19
82	280781	Mann C N	852	80784	Chick	29
83	290781	Antelope	852	80785	Chick	14
84	290781	Antelope	852	80786	Chick	16
85	150881	Mann C S	852	80787	Juvenile	67
86	150881	Mann C S	852	80788	Juvenile	54
87	170881	Mann C S	852	80789	Chick	49
88	260881	Mann C N	852	80790	Juvenile	67
89	290881	Mann C N	852	80791	Juvenile	58
90	290881	Mann C N	852	80792	Juvenile	64
91	220482	Many Deer	852	80793	Adult	108
92	230482	Rob Cowcamp	852	80794	Adult	107
93	230482	Well Res	852	80795	Adult	116
94	230482	Well Res	852	80796	Adult	106
95	240482	Many Deer	852	80797	Adult	114
96	240482	Many Deer	852	80798	Adult	104
97	10582	Antelope	852	80799	Adult	121
98	10582	Well Res	852	80800	Adult	108
99	130582	Morgan	902	50901	Adult	128
100	130582	Morgan	902	50902	Adult	94
101	130582	Antelope	902	50903	Adult	126
102	130582	Rob Cowcamp	902	50904	Adult	124
103	140582	Mann C N	902	50905	Adult	132
104	140582	Mann C S	902	50906	Adult	129
105	140682	Antelope	902	50907	Chick	12
106	140682	Antelope	902	50908	Chick	12
107	140682	Antelope	902	50909	Adult	105
108	170682	Mann C N	902	50910	Adult	104
109	260682	Many Deer	902	50911	Chick	12
110	280682	Antelope	902	50912	Chick	40

Appendix B continued.

Bird Number	Date	Prairie Dog Town	Band Prefix	Band Number	Age	Weight (g)
111	280682	Antelope	902	50913	Chick	40
112	40782	Antelope	902	50914	Chick	11
113	40782	Antelope	902	50915	Chick	11
114	40782	Rob Cowcamp	902	50916	Chick	48
115	50782	Abu	902	50917	Chick	46
116	60782	Many Deer	902	50918	Adult	103
117	70782	Antelope	902	50919	Chick	10
118	70782	Antelope	902	50920	Chick	11
119	70782	Antelope	902	50921	Chick	42
120	90782	Hawley Coulee	902	50922	Juvenile	59
121	90782	UL Bend Airstrip	902	50923	Chick	11
122	100782	Dead Calf N	902	50924	Juvenile	52
123	110782	Mann C N	902	50925	Chick	11
124	110782	Mann C N	902	50926	Chick	11
125	110782	Mann C N	902	50927	Chick	11
126	130782	Damn Creek Res	902	50928	Juvenile	74
127	190782	Mann C N	902	50929	Chick	20
128	190782	Mann C N	902	50930	Chick	27
129	20882	Antelope	902	50931	Juvenile	58
130	30882	Many Deer	902	50932	Juvenile	68
131	40882	Mann C N	902	50933	Juvenile	56
132	100882	Mann C N	902	50934	Chick	26
133	100882	Mann C N	902	50935	Chick	24
134	200882	Well Res	852	80718	Adult	102